RUBBER POSTS USED AS
VEHICLE SPEED REDUCERS

PRELIMINARY

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This publication's contents reflect the opinions, findings, and conclusions of the New York State Department of Transportation, and not necessarily those of the Bureau of Public Roads.

PRELIMINARY

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Gift of Jim Bryden.

ABSTRACT

Three dynamic full-scale tests were performed on a rubber post vehicle speed reducer marketed under the name SAF-T-POST. The posts were to be used to stop a vehicle, traveling at highway speeds, before it entered a hazardous area. Tests conducted by the manufacturer had been limited to a single row of posts. In our tests an array of six posts was evaluated.

Tests were performed at 15, 25, and 35 mph. Average deceleration of the test vehicle ranged from 0.43 g to 0.51 g. It was found that using an array of these posts, a 260 foot stopping distance would be required if the vehicle (3,500 lbs.) was traveling at 60 mph and 360 feet at 70 mph.

At speeds over 25 mph there was a tendency for the vehicle to be lifted by the rubber posts. At speeds over 35 mph, vehicle lift occurred and the tires lost contact with the ground.

There was no damage to the SAF-T-POST product in any of our tests. Vehicle damage could not be evaluated because of a special "bumper" installed on the vehicle. It is felt that no serious vehicle damage would have occurred if the vehicle's original bumper had been left in place.

The use of SAF-T-POST posts as a delineator was reviewed. However, because of the initial cost of the post ($70 to $80 each), if is felt that this application would be uneconomical.

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INTRODUCTION

when specifically please

In the early 1950's, the Goodyear Tire and Rubber Company, in cooperation with the City of Cuyahoga Falls, Ohio, installed what might be termed a first generation vehicle speed reducer. The speed reducer was a series of rubber posts set in a row so that one after another they would be hit by an out-of-control vehicle. Friction between the post and bottom of the vehicle as well as bending of the posts was expected to stop the vehicle.

The flexible rubber posts were adapted from a rubber dock bumper produced by Goodyear. Each post was a hollow rubber cylinder 54 inches long, and 7 inches in diameter. Inside the post a 33 inch steel pipe, three inches in diameter was mounted so that 12 inches projected out of the base. The post was then embedded in concrete so that 36 inches of rubber projected out of the ground (see Figure 1a).*

In the late 1950's, a company producing a product marketed under the name SAF-T-POST, approached the New York State Department of Transportation (at the time the Department of Public Works), in an attempt to interest the State in using SAF-T-POSTS for highway applications. The posts produced by SAF-T-POST were essentially the same as those used by Goodyear in Cuyahoga Falls, Ohio (see Figure 1b).

In a brochure** published by SAF-T-POST, the manufacturer suggests the following applications for his product:

1. On driveway entrances, corners of buildings, ends of guide rails, etc.

2. Around fire hydrants

3. In front of bridge abutments

*

**

[illegible]

In [illegible] 1964, the Goodyear Tire and Rubber Company, in cooperation with the City of Cuyahoga Falls, Ohio, installed what might be termed a [illegible] with the speed reducer. The speed reducer was a series of rubber posts set in a curve that was either [illegible] that would be hit by an out-of-control vehicle. [illegible] between the post and bottom of the vehicle as well as [illegible] of the post was expected to stop the vehicle.

The first posts used [illegible] were adapted from a rubber dock [illegible] produced by Goodyear. Each post was a hollow rubber cylinder 18 inches long, and 7 inches [illegible] diameter. Inside the post a 20 inch steel pipe [illegible] was bonded to that 18 inches [illegible] of the [illegible]. The post was then embedded in concrete to [illegible] the [illegible] of the ground (see Figure 1).

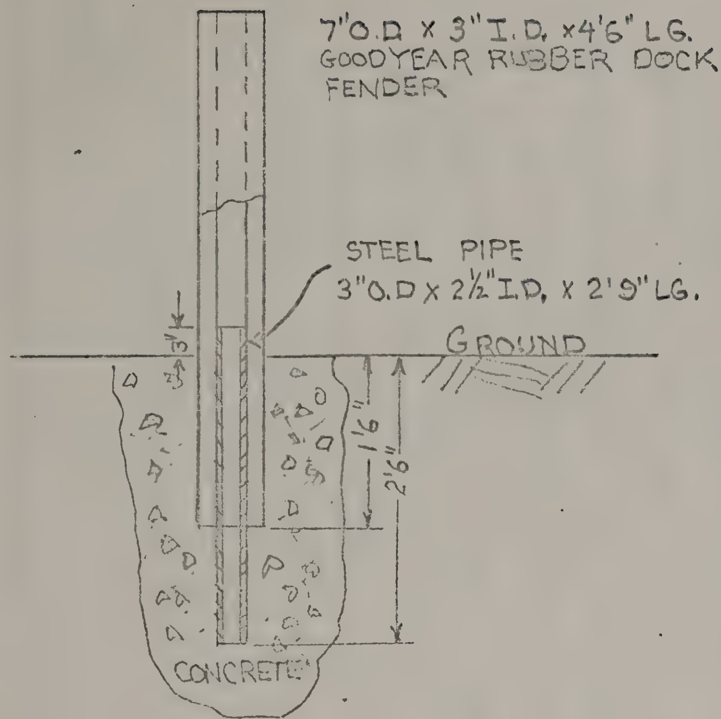
In the late 1960's, a company [illegible] a product marketed under the name SAF-T-POST, approached the New York State Department of Transportation (at the time the Department of Public Works), in an attempt to interest the State in using SAF-T-POSTs for highway applications. The posts produced by SAF-T-POST were essentially the same as those used by Goodyear in Cuyahoga Falls, Ohio (see Figure 2).

In a brochure published by SAF-T-POST, the manufacturer suggests the following applications for the product:

1. As delineator [illegible] of abutments, ends of guide rail, etc.

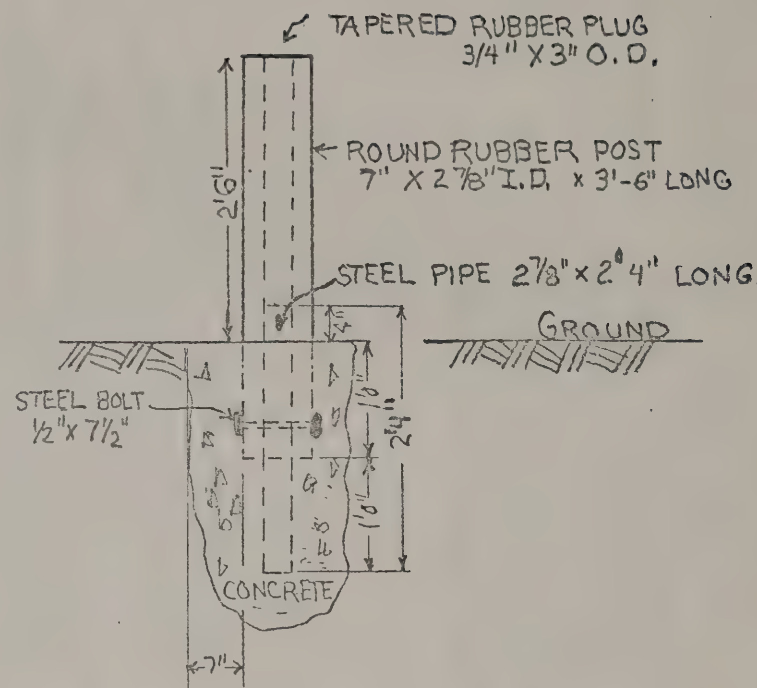
2. [illegible]

3. [illegible]



GOODYEAR POST

Figure 1a



SAF - T- POST

Figure 1b

FIGURE 1 COMPARISON OF GOODYEAR AND SAF-T- POST RUBBER POST SPEED REDUCER

4. On and ahead of traffic islands

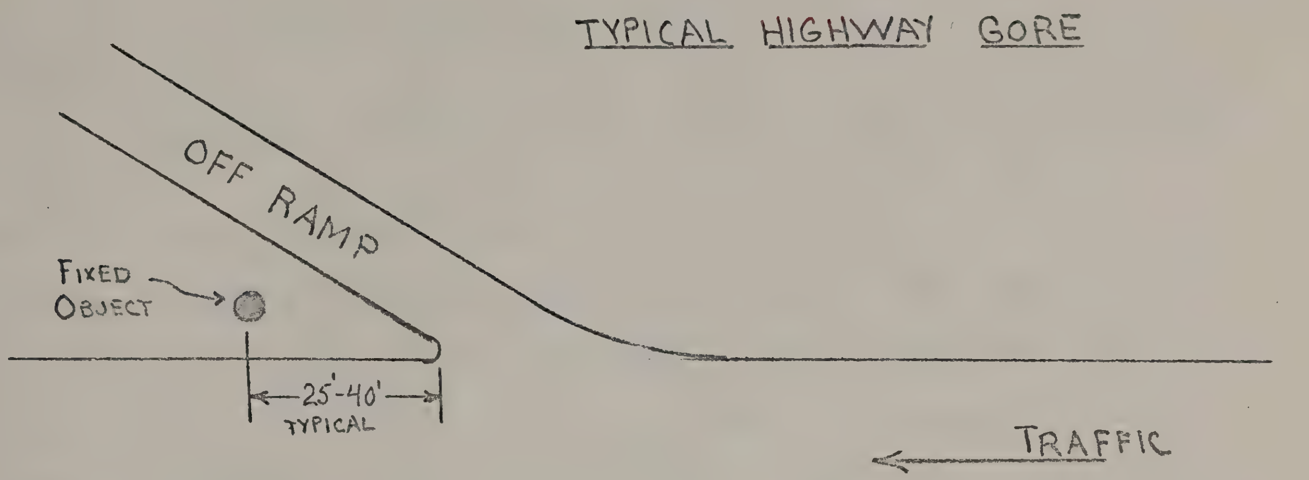
The manufacturer does not suggest whether the primary function of the SAF-T-POST is one of delineation or one of stopping the vehicle before it enters a hazardous area. Since no technical information was provided in the brochure, it was difficult to tell which function these posts might be used for.

The use of the SAF-T-POST rubber posts as a delineator would be uneconomical. A cost of $100 per post was suggested by the manufacturer and he thought that the cost could be reduced 20-30% by volume sales. Even if the post required no maintenance after impact, the cost of $70 to $80 per post would be excessive for a delineator. Other maintenance free delineators are available at a fraction of this cost.

It is reasonable to assume the manufacturer intended his product to be used primarily as a device to stop vehicles before they entered a hazardous area. However, since no technical or design data was provided it was difficult to predict how this might be accomplished (number of posts required for given design speed, stopping distances, etc.).

For applications specified by the manufacturer, it would generally be more desirable to redirect a vehicle using guide rail. This is, however, one important area on a highway where redirection is not possible and to stop a vehicle would be desirable.

This area is known as the "gore", and it is illustrated below. In the gore region, it is desirable to stop a vehicle



within reasonable deceleration limits, if the car is on a head-on collision course with the rigid object. For oblique type impacts redirection would be desirable.

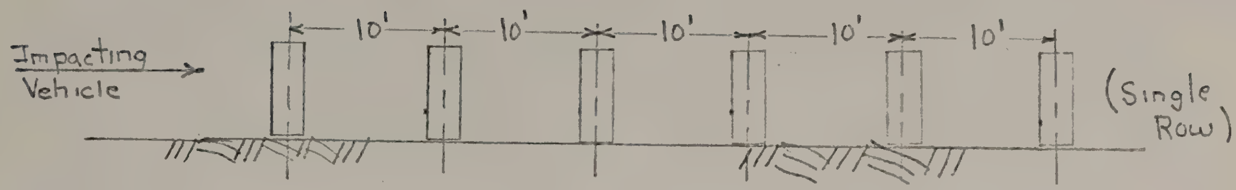
Examination of existing gores on highways indicate that there is about 25-40 feet available to stop a car. In order to stop a vehicle, traveling at 60 mph, an average deceleration of between 4.8 "g" (25 ft) and 3 "g" (40 ft) would be required for our typical gores. Thus, any device installed in typical 40 ft gore has to apply a retarding force at least equal to 3 times the weight of the vehicle.

The SAF-T-POST company furnished the State with the following full-scale crash test information relative to their product:

*"Flexible Highway Posts", Fleet Owner, April 1964, p. 100

**"Be Prepared" SAF-T-POST, 298 Main Street, Buffalo, New York

TEST RESULTS
DATE OF TEST: October 22, 1957
LOCATION OF TEST: Buffalo, New York
POST ARRANGEMENT:



VEHICLE USED: Mercury Sedan

Test 1: Vehicle hit posts between 45-50 mph. When the car hit the first post, the gas was removed, but the brakes were not applied. The car rolled off the 6th post at between 10-15 mph.

Test 2: Vehicle hit the first post at 45 mph. The brakes were set as soon as the car hit the first post. The car stopped on top of the third and fourth post and required aid in moving over the posts.

It is appropriate to point out that these test results were based on visual observation rather than engineering documentation; therefore, it was not possible to determine the true impact speeds, and in the case of Test 1, the roll-off speed. From these tests it was obvious that relatively large deceleration distances were required to slow and stop a car traveling at about 45 mph.

Based on test results furnished by the manufacturer, a decision was made that the SAF-T-POST was not suitable for highway use. The basis for this decision was the relatively low rate of deceleration and consequently the long stopping distance required. The product SAF-T-POST was dropped from further consideration at that time.

Originally, tests performed on the SAF-T-POST product were limited to a single row of posts. In 1968, it was decided to test the SAF-T-POST product and to obtain engineering data on which to gauge its potential application when placed in an array. Therefore, as part of an ongoing test program, several tests were performed on the SAF-T-POST product to obtain the desired information.

TEST METHOD

Full-scale tests were conducted on the SAF-T-POST rubber posts on July 10, 1969. The test site was the Schenectady County Airport, Schenectady, New York.

Six rubber posts were purchased from SAF-T-POST at a cost of $100/post. For test purposes, they were set in the array described in Figure 2. This figure also illustrates the location of the data camera.

A 1963 Plymouth sedan was used as a test vehicle. Since only one vehicle was available for use in the rubber post tests, it was decided to mount a 6 x 8 inch section of box beam in place of the vehicle's front bumper. This beam section was installed to eliminate any vehicle crush which might occur, thus keeping the frontal area of the car uniform for all the tests. Photographs of the test vehicle and the rubber post array are shown in Figure 3.

The test vehicle was instrumented in accordance with procedures common to our guide rail tests. Targets spaced 40 inches apart were placed on top of the vehicle roof. These targets were used in the film analysis to provide two common reference points on the vehicle. A RM 3-way accelerometer, produced by the IMPACT REGISTER COMPANY was installed on the floor of the vehicle inside the passenger compartment. The full-scale range of the accelerometer was ±20g's with resolution to 0.5g's. The purpose of this device was to give immediate indications of the decelerations reached in the tests without having to perform time consuming film analysis.

The crash car was guided to the impact point by a track and dolly arrangement. A detailed explanation of the method of control-

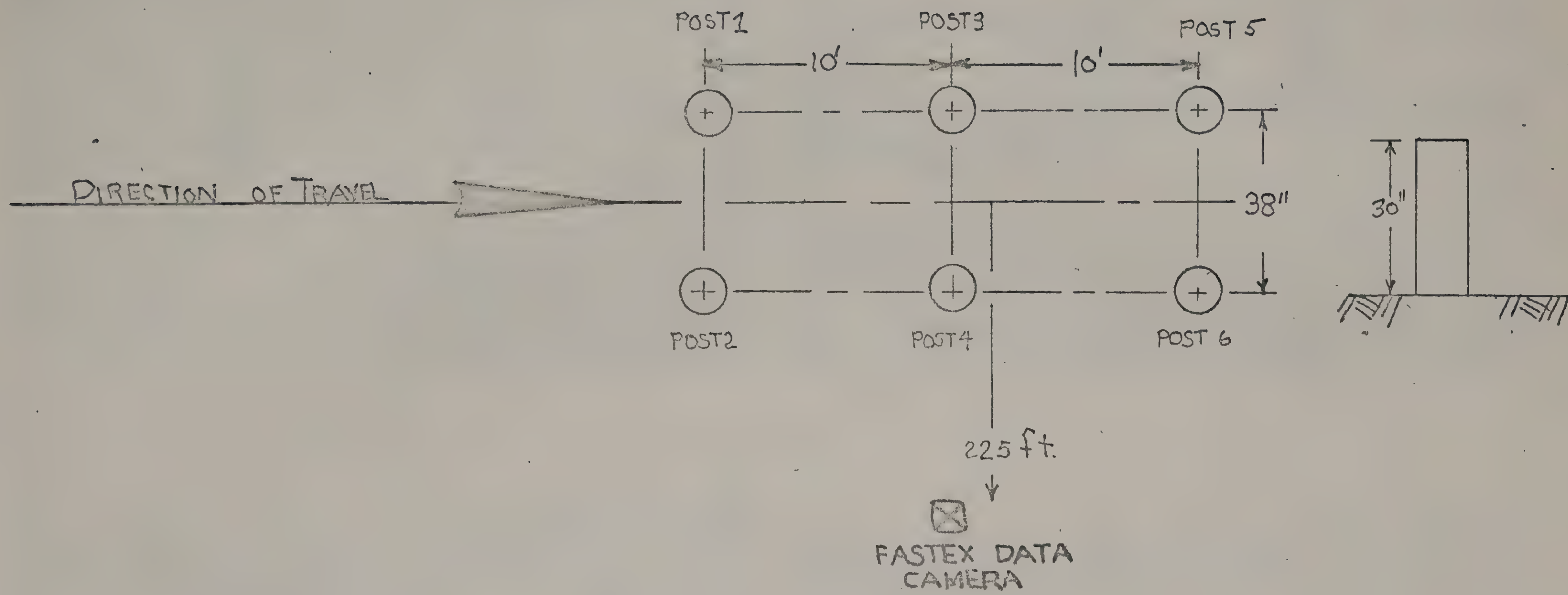


FIGURE 2 SAF-T-POST TEST ARRAY

Figure 3. Test vehicle and rubber post array used for Tests 87, 88, 89, and 90.

ling the vehicle is not pertinent to this report; and, it will be covered in a future research report describing our complete test program.

The tow car driver controlled the speed of the crash vehicle. He was able to read this tow car speedometer and thus provide an estimate of impact speed to observers watching the tests. This estimate was later used to check impact speeds obtained from film analysis.

Data Collection and Analysis Method

At the onset of the test program, it was anticipated that large diameter rubber posts would reduce the speed of a vehicle through two physical actions:

1. Bending and inertial resistance of the posts at impact.
2. Friction between the posts and the undercarriage of the car as it passes over the bent posts.

A graph illustrating, in general, what we felt might occur in our tests is shown in Figure 4. Using the array of posts tested (shown in Figure 2), it was anticipated that vehicle speed changes would occur in eight areas. Referring to Figure 4 these speed change areas can be explained as follows:

Speed Change Area	Reason for Speed Change
Vi	Symbol representing the initial velocity of the car as it impacts posts 1 & 2.
Area 1 ($\triangle V_1$)	Car bends posts 1 & 2. Slowing action is due to bending and inertial resistance of these posts.
Area 2 ($\triangle V_2$)	Car slows due to the friction of posts 1 & 2 against the bottom of the car.
Area 3 ($\triangle V_3$)	Bending and inertial resistance of posts 3 & 4 while posts 1 & 2 still create friction under the car.
Area 4 ($\triangle V_4$)	Slowing due to friction of posts 1 & 2 and 3 & 4. Slowing rate should be different than V_2 because a different % of vehicle weight is on posts.
Area 5 ($\triangle V_5$)	Bending and inertial resistance of posts 5 & 6 being partially bent. Posts 1 & 2 and 3 & 4 create friction.
Area 6 ($\triangle V_6$)	Rear of vehicle off posts 1 & 2. Car slowing due to further bending resistance of posts 5 & 6 and friction from posts 3 & 4.

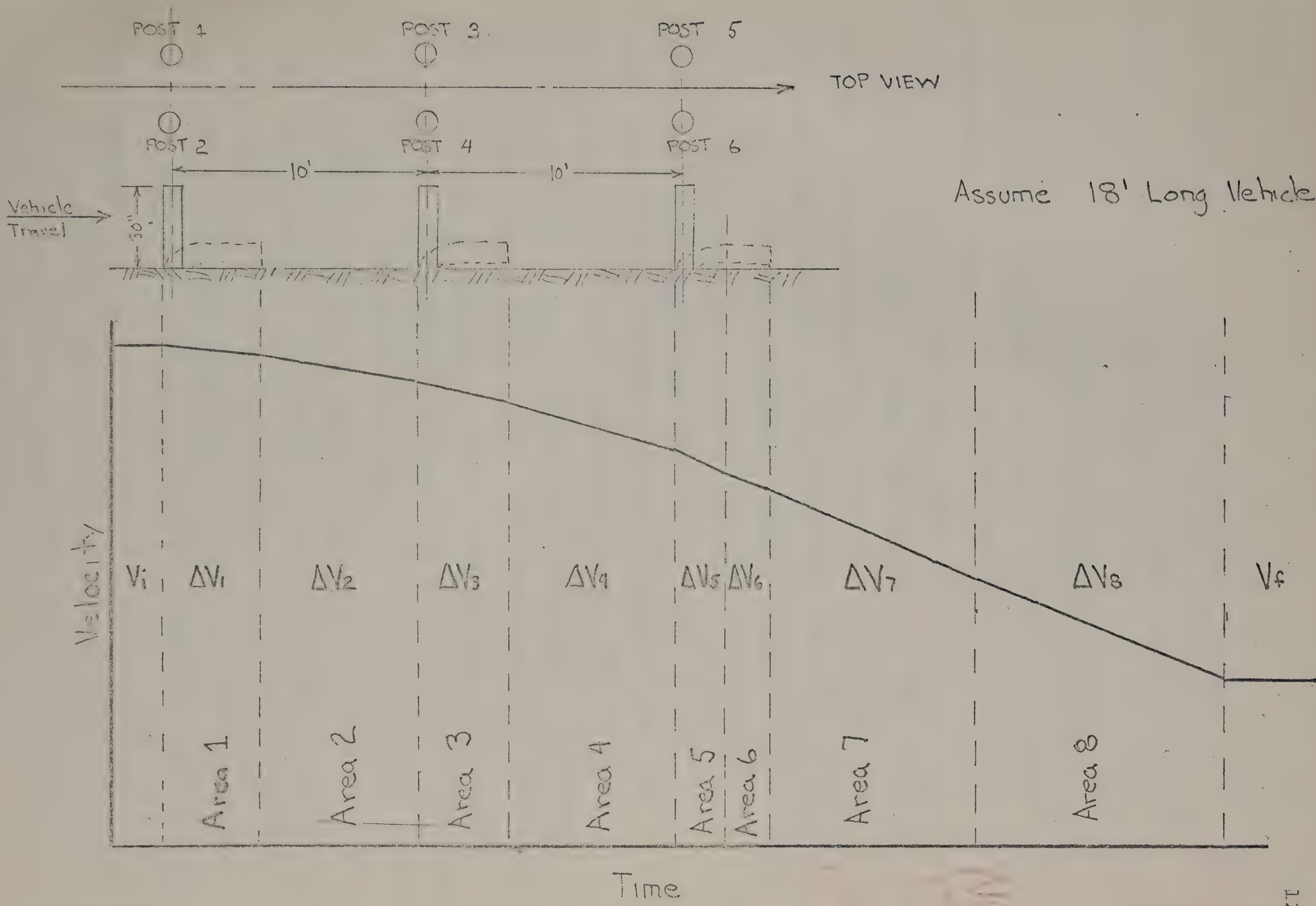


FIGURE 4 - Expected Speed Change Areas

Area 7 ($\triangle V_7$) — Car slowing because of friction created by posts 3 & 4 and 5 & 6.

Area 8 ($\triangle V_8$) — Car off posts 3 & 4. Friction of posts 5 & 6 slow car.

Vf. — Symbol representing the final velocity of the car as it leaves the posts.

It was originally hoped that these speed changes could be defined during testing. However, analysis of the data did not reveal the anticipated speed change areas.

The procedure used to collect and analyze the data was as follows: A high speed FASTEX cine' camera, operating at about 500 frames per second was used to photograph the test vehicle (see Figure 2 for camera location). Timing reference marks were recorded on the edge of the film at the rate of 120 marks per second. After development, the film was projected onto a Benson Lehner Scanner (analog to digital converter), and the displacement of the vehicle was measured every 5th timing mark ($5 \times 1/120 = .042$ seconds). Using this displacement-time data, average vehicle velocity for each .042 second period was calculated with the aid of a computer. Graphs of vehicle velocity vs. time were made and are displayed in Figures 5, 6, and 7. After reviewing these graphs it was decided that our standard data reduction program was not appropriate for the data gathered during the tests on rubber post speed reducers. The reason for this was because at the low test speeds, small errors in measurement of vehicle displacement resulted in relatively large errors in vehicle velocity. It was decided that the velocity graphs could be "smoothed" using mathematical methods.

Displacement vs. time data were graphed as shown in Figures 8, 9, and 10. The data closely approximated the general form of a

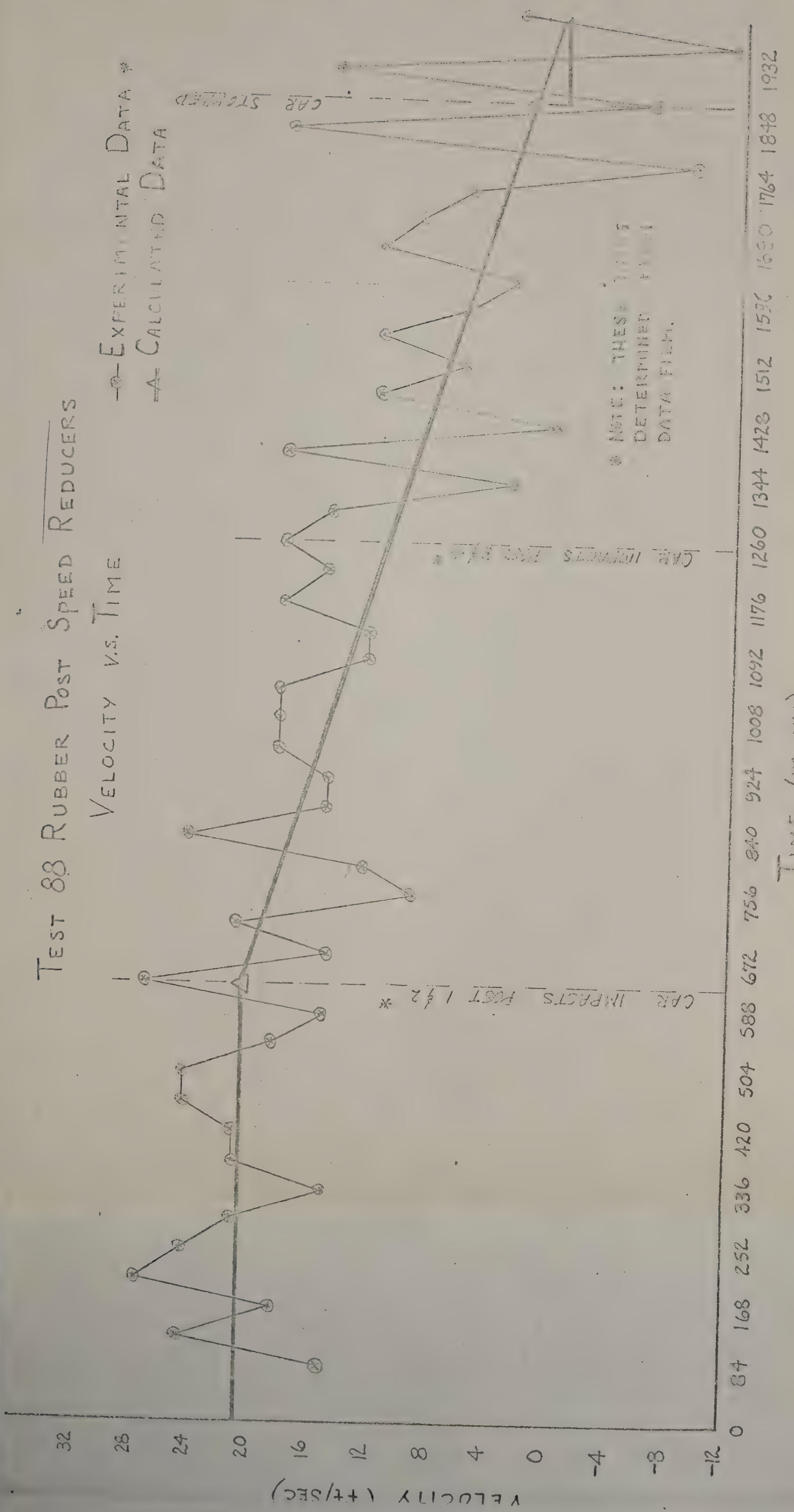

TEST 88 RUBBER POST SPEED REDUCERS
VELOCITY V.S. TIME
EXPERIMENTAL DATA
CALCULATED DATA
CAR STOPPED
CAR IMPACTS POST 1 1/2
VELOCITY (ft/SEC)
32
28
24
20
16
12
8
4
0
-4
-8
-12
0
84
168
252
336
420
504
588
672
756
840
924
1008
1092
1176
1260
1344
1428
1512
1596
1680
1764
1848
1932
TIME (m SEC)

FIGURE 5

Test 89 Rubber - Post Speed Reducers

Velocity v.s. Time

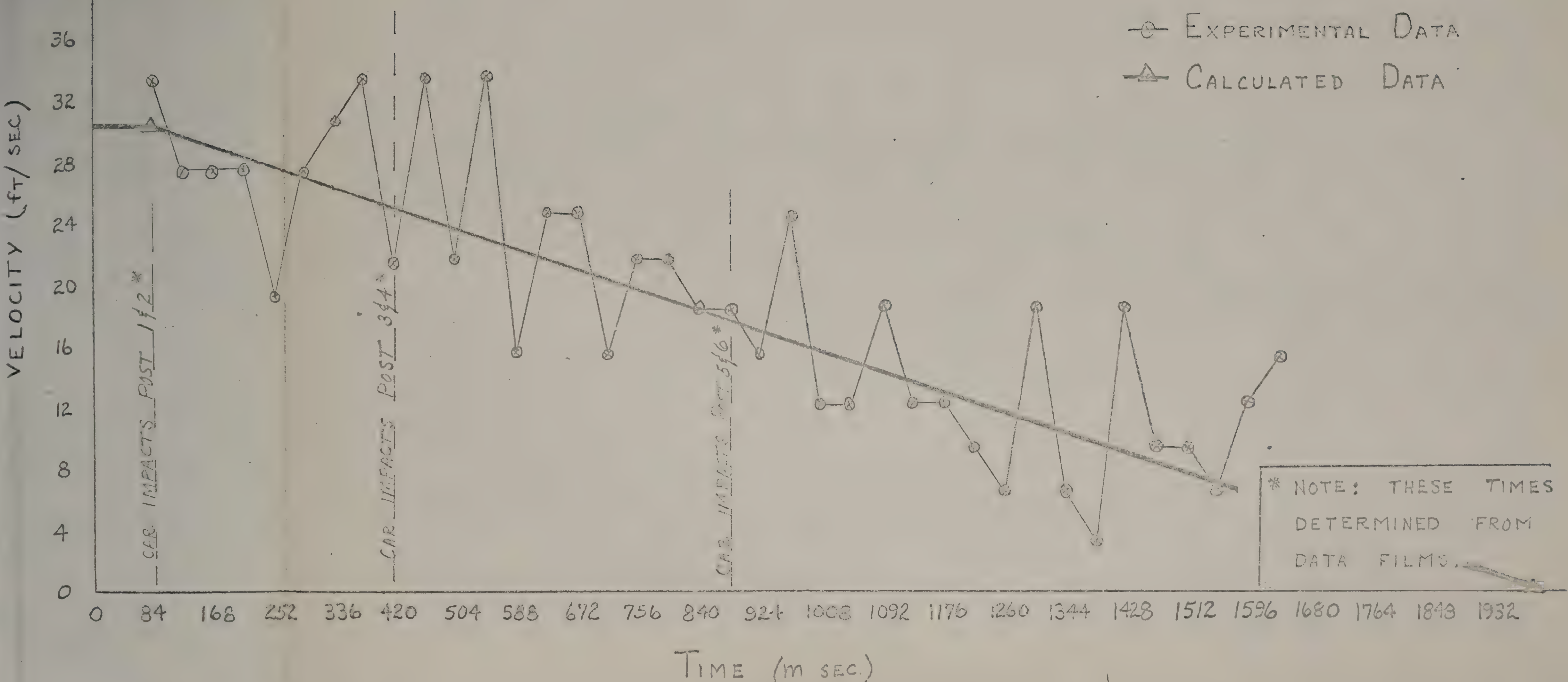


FIGURE 6

TEST 90 RUBBER POST SPEED REDUCER

VELOCITY V.S. TIME

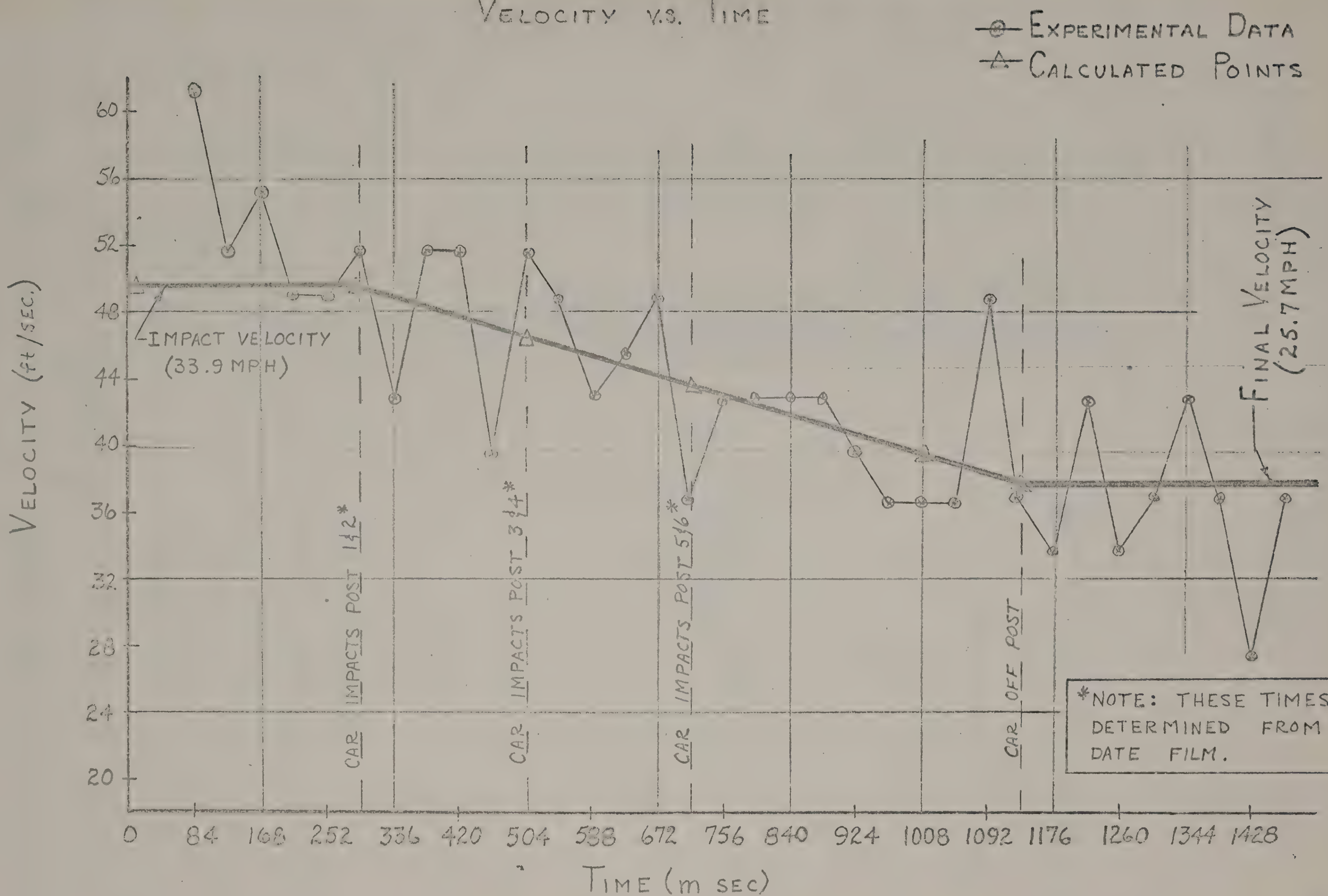


FIGURE 7

POLYNOMIAL REGRESSION (GCSL012)

BACK SOLUTIONS FOR POLYNOMIAL OF DEGREE 2

X VALUE (1)	Y VALUE (2)	EST. Y*
0.6300	-16.8200	-17.3113
0.6720	-16.1800	-16.4398
0.7140	-15.2800	-15.5930
0.7560	-14.8900	-14.7708
0.7980	-14.3800	-13.9734
0.8400	-13.3500	-13.2006
0.8820	-12.7100	-12.4526
0.9240	-12.0700	-11.7292
0.9660	-11.3000	-11.0305
1.0080	-10.5300	-10.3566
1.0500	-9.7600	-9.7073
1.0920	-9.2400	-9.0827
1.1340	-8.7300	-8.4828
1.1760	-7.9600	-7.9076
1.2180	-7.3200	-7.3571
1.2600	-6.5500	-6.8312
1.3020	-5.9100	-6.3301
1.3440	-5.7800	-5.9649
1.3860	-5.0100	-5.4019
1.4280	-5.0100	-4.9749
1.4700	-4.5000	-4.5725
1.5120	-4.2400	-4.1948
1.5440	-3.7300	-3.9237
1.5960	-3.4700	-3.5136
1.6380	-3.3400	-3.2100
1.6800	-2.8300	-2.9311
1.7220	-2.5700	-2.6769
1.7640	-2.3100	-2.4474
1.8060	-2.7000	-2.2425
1.8480	-1.9300	-2.0624
1.8900	-2.1800	-1.9070

*Best fit line - from equation (1)

(1) X is time in seconds

(2) Y is displacement in feet

POLYNOMIAL DEGREE= 2

TERM DEGREE	COEFFICIENT
0	-.33347163E 02
1	.29863107E 02
2	-.69989865E 01

EQUATIONS:

Limits: 0.630 to 1.870 seconds

(1) Displacement (Y) $= -33.35 + 29.86t - 7.00t^2$

(2) Velocity (ft/sec) $= 29.86 - 14.00t$

(3) Acceleration $= 14$ ft/sec^2

where t is in seconds

TABLE 1

TEST 88 POLYNOMIAL REGRESSION RESULTS

BACK SOLUTIONS FOR POLYNOMIAL OF DEGREE 2

* Best fit - from equation (1)

(1) X is time in seconds

(2) Y is displacement in feet

X VALUE (1)	Y VALUE (2)	EST. Y*
0.0840	-16.3100	-16.5964
0.1260	-15.1500	-15.3216
0.1680	-13.9900	-14.0754
0.2100	-12.8400	-12.8578
0.2520	-12.0700	-11.6687
0.2940	-10.9100	-10.5083
0.3360	-9.6300	-9.3763
0.3780	-8.2200	-8.2730
0.4200	-7.3200	-7.1982
0.4620	-6.1600	-6.1520
0.5040	-5.2600	-5.1344
0.5460	-3.8500	-4.1454
0.5880	-3.2100	-3.1849
0.6300	-2.1800	-2.2530
0.6720	-1.1600	-1.3496
0.7140	-0.5100	-0.4749
0.7560	0.3900	0.3713
0.7980	1.2800	1.1890
0.8400	2.0500	1.9780
0.8820	2.8200	2.7385
0.9240	3.4700	3.4704
0.9660	4.4900	4.1737
1.0080	5.0100	4.8485
1.0500	5.5200	5.4947
1.0920	6.2900	6.1123
1.1340	6.8000	6.7014
1.1760	7.3200	7.2616
1.2180	7.7000	7.7937
1.2600	7.9600	8.2971
1.3020	8.7300	8.7718
1.3440	8.9900	9.2180
1.3860	9.1200	9.6356
1.4280	9.8900	10.0247
1.4700	10.2700	10.3851
1.5120	10.6600	10.7170
1.5440	10.9100	10.9507
1.5960	11.4300	11.2951
1.6380	12.0700	11.5413

POLYNOMIAL DEGREE= 2

TERM DEGREE	COEFFICIENT
0	-.19231674E 02
1	.32052477E 02
2	-.80986270E 01

EQUATIONS:

Limits: 0.084 to 2.116 seconds

(1) Displacement (Y) = $-19.23 + 32.05t - 8.10t^2$

(2) Velocity (ft/sec) = $32.05 - 16.20t$

(3) Acceleration = -16.20 ft/sec^2

where t is in seconds

TABLE 2

TEST 89 POLYNOMIAL REGRESSION RESULTS

POLYNOMIAL REGRESSION (GCSL012)

BACK SOLUTIONS FOR POLYNOMIAL OF DEGREE 2

X VALUE(1)	Y VALUE(2)	EST. Y*
0.2940	-14.6400	-14.7390
0.3360	-12.8400	-12.6646
0.3780	-10.6600	-10.6169
0.4200	-8.4700	-8.5959
0.4620	-6.8000	-6.6017
0.5040	-4.6200	-4.6341
0.5460	-2.5700	-2.6934
0.5880	-0.7700	-0.7793
0.6300	1.1600	1.1080
0.6720	3.2100	2.9686
0.7140	4.7500	4.8024
0.7560	6.5500	6.6096
0.7980	8.3500	8.3900
0.8400	10.1400	10.1436
0.8820	11.9400	11.8705
0.9240	13.6100	13.5707
0.9660	15.1500	15.2442
1.0080	16.6900	16.6909
1.0500	18.2300	18.5109
1.0920	20.2900	20.1042
1.1340	21.8300	21.6707
1.1760	23.2400	23.2105

* Best fit line - from equation (1)

(1) X is time in seconds

(2) Y is displacement in feet

POLYNOMIAL DEGREE= 2

TERM DEGREE	COEFFICIENT
0	-.30008607E 02
1	.54165037E 02
2	-.75771180E 01

EQUATIONS:

Limits: 0.294 to 1.134 seconds

(1) Displacement (Y) = $-30.01 + 54.17t - 7.58t^2$

(2) Velocity (ft/sec) = $54.17 - 15.16t$

(3) Acceleration = -15.16 ft/sec^2

where t is in seconds

TABLE 3

TEST 90 POLYNOMIAL REGRESSION RESULTS

TEST 88 RUBBER POST SPEED REDUCER
DISPLACEMENT V.S. TIME

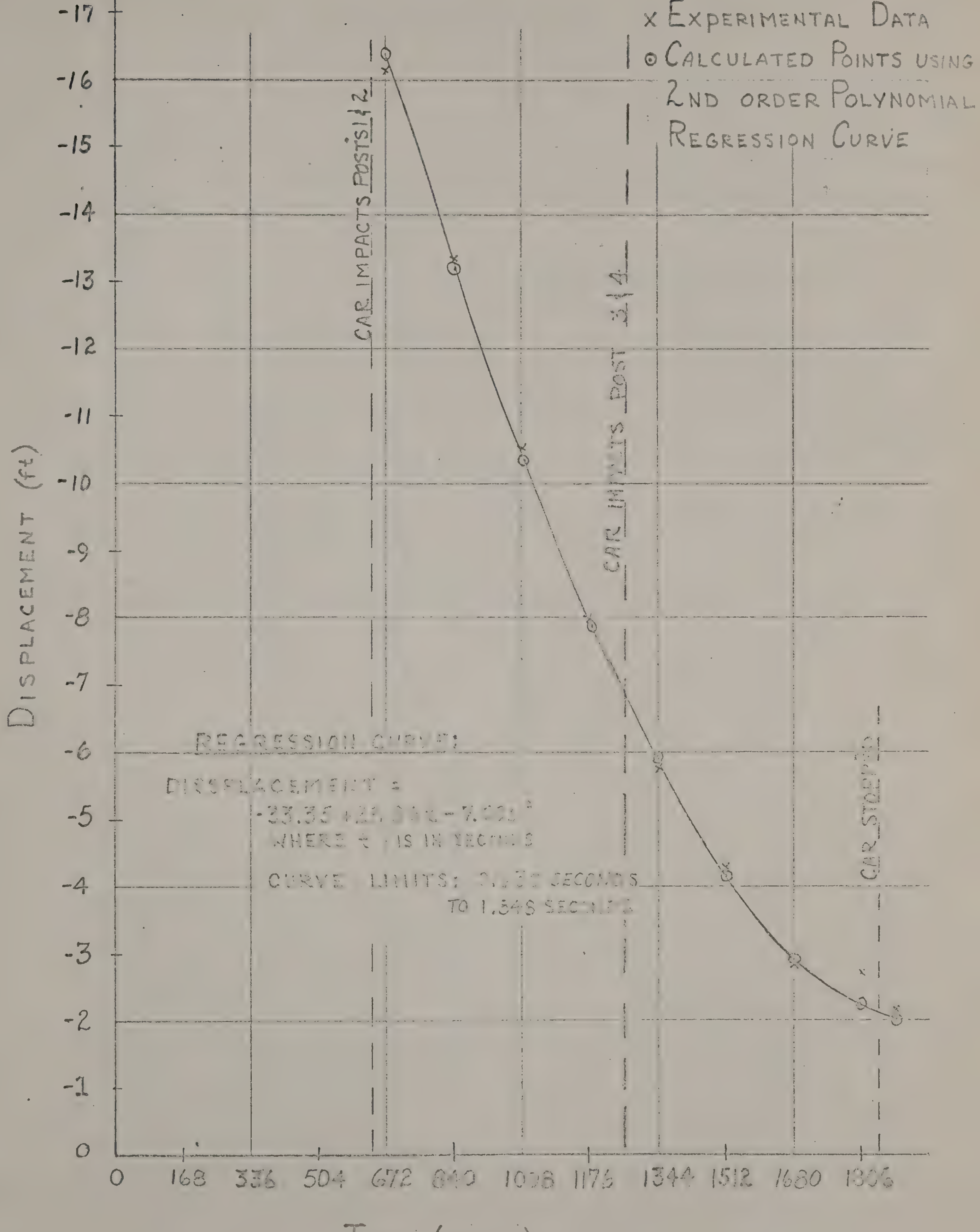
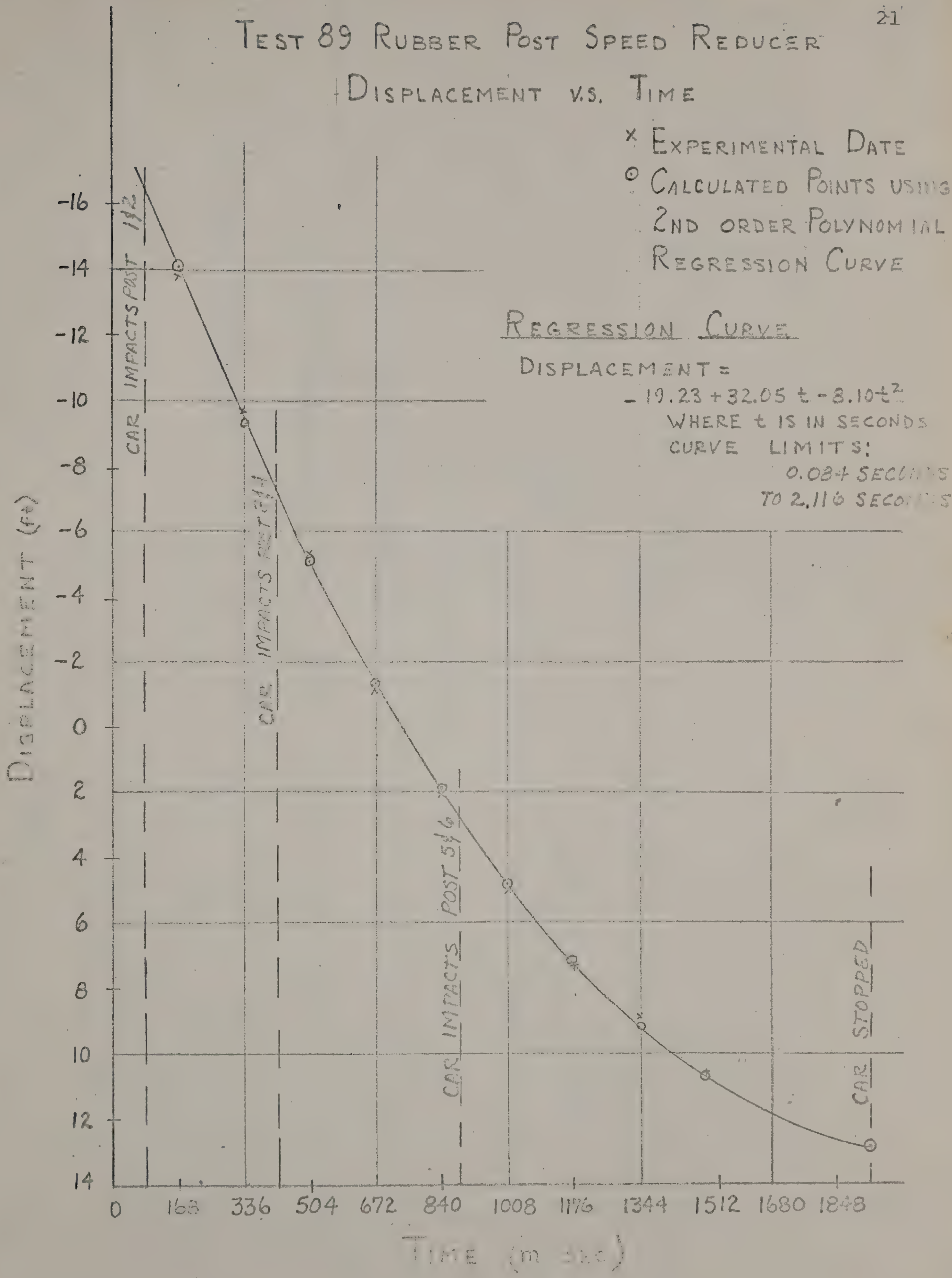


FIGURE 8



Test 89 Rubber Post Speed Reducer
Displacement v.s. Time
× Experimental Date
⊙ Calculated Points using 2nd order Polynomial Regression Curve
Regression Curve
Displacement = - 19.23 + 32.05 t - 8.10t²
Where t is in seconds
Curve limits: 0.084 seconds to 2.116 seconds
Car impacts post 1 & 2
Car impacts post 3 & 4
Car impacts post 5 & 6
Car stopped
Displacement (ft)
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
14
0
168
336
504
672
840
1008
1176
1344
1512
1680
1848
Time (m sec)

FIGURE 9

TEST 90 RUBBER POST SPEED REDUCER

DISPLACEMENT V.S. TIME

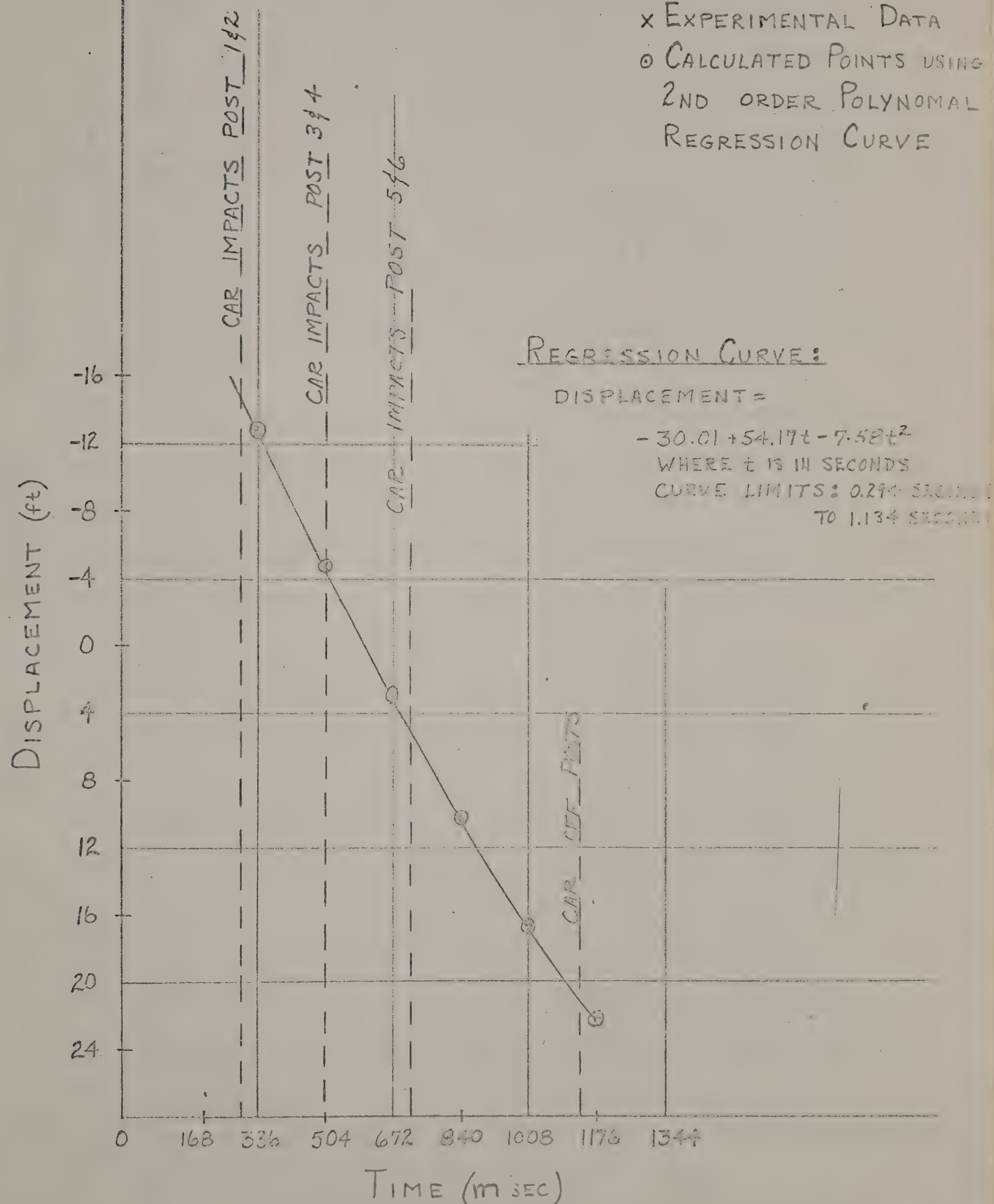


FIGURE 10

parabola which would be expected if deceleration were constant. Because of this it was decided to assume constant deceleration. With the aid of the computer, the "best" fit 2nd order polynomial curve was fitted to the data. Tables 1, 2, and 3 show the results of the computer fit. The estimated Y values (displacement) were plotted in Figures 8, 9, and 10 along with the experimental data. The estimated Y values found in the polynomial fit did not vary more than 2% from the test data. It was, therefore, reasoned that the polynomial fit adequately described the test data for all practical purposes.

Also illustrated in Tables 1, 2, and 3 are general equations (as found by computer solution) describing the test during the period the car was in contact with the rubber posts. The first derivative (Equation (2)) of the displacement equation (1) describes the velocity of the vehicle. The constant in the velocity equation (2) is equal to the impact velocity (feet/second).

The second derivative (Equation (3)) of the displacement is the deceleration of the vehicle. Since the 2nd order polynomial (parabolic function) was used, this deceleration was a constant.

Inspection of the accelerometer tapes (RM-3 way installed in the vehicle) showed that decelerations did not exceed 1 "g" during any of the tests and averaged about 0.5"g's". These accelerometer traces found in Figure 11, serve to verify the decelerations computed from the high speed data films, and substantiate that vehicle deceleration was reasonably constant during impact and overriding of the posts.

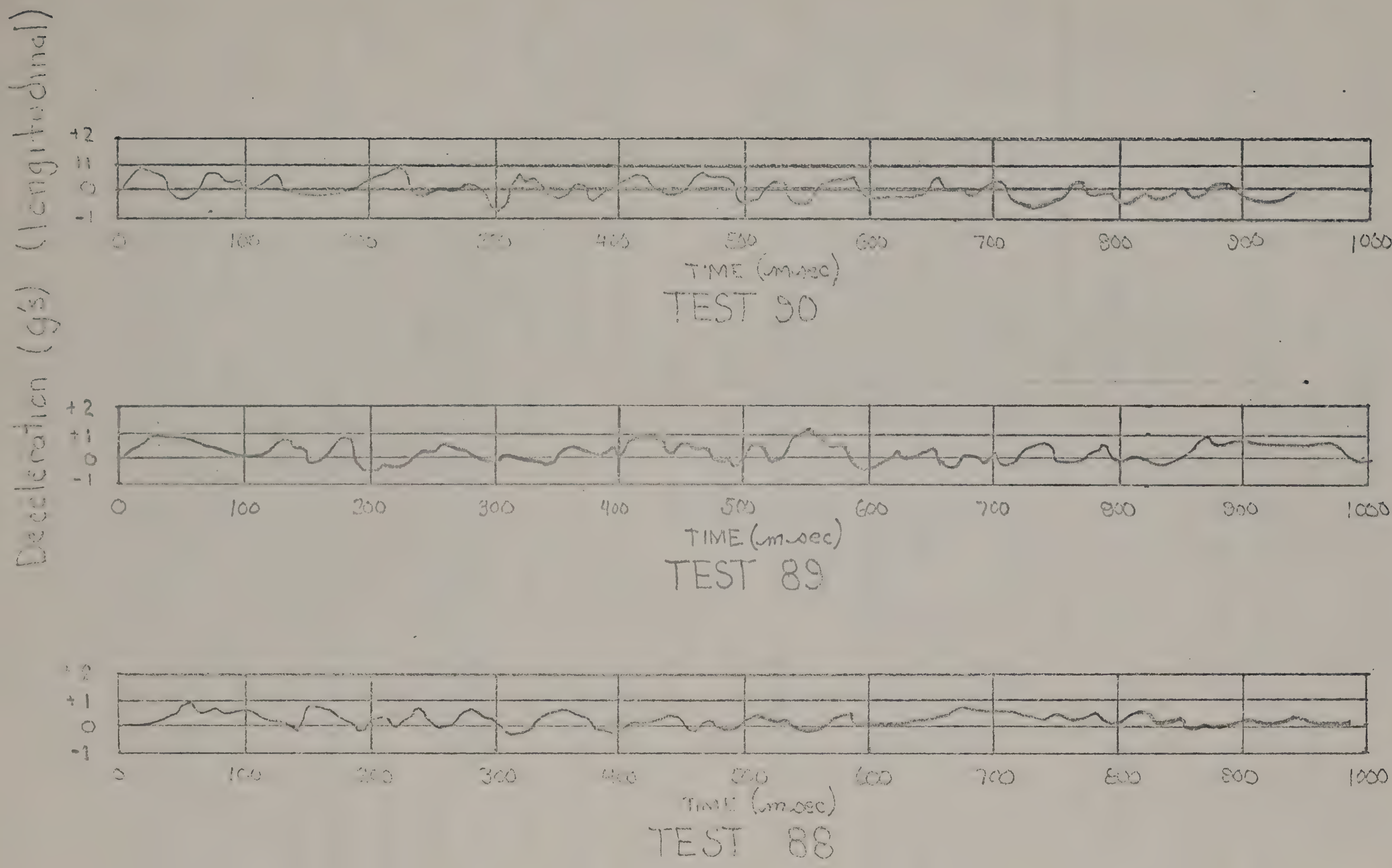


FIGURE 11 Accelerometer Tape Readings - Test 88, 89 and 90

TEST RESULTS

Four tests were performed on the array of six rubber posts (SAF-T-POST). One test (Test 87) is not summarized because the tow dolly did not release from the test car and it was pulled over all of the posts by the tow car. Although no engineering data could be obtained from Test 87, it is significant to point out that the rubber post array did not offer enough resistance to prevent the tow car from pulling the test car over all six posts at a speed of approximately 15 mph.

In Tests 88, 89, and 90, the tow car driver estimated the impact speeds to be 15, 25, and 35 mph, respectively. Impact speeds for these tests, obtained by analysis of the high speed movie films were 14.4, 21.0, and 33.9 mph.

Figures 12, 13, and 14 summarize the results of the three tests. Referring to these summaries, one can note that the vehicle stopped on the posts in Test 88 (14.4 mph) and Test 89 (21.0 mph). Stopping distances in these tests were 14.3 feet and 29.1 feet respectively. Average decelerations computed from these stopping distances were 13.8 ft/sec^2 (0.43 x accel. of gravity) and 16.4 ft/sec^2 (0.51 x accel. of gravity). In Test 90, the vehicle had an impact velocity of 33.9 mph and rolled off the posts with a final velocity of 25.7 mph. As in the previous tests, the average deceleration was computed during the period the car was in contact with the posts and indicated the test vehicle slowed at 15.1 ft/sec^2 (0.47 x accel. of gravity ie. 0.47 "g").

One might be surprised by the fact that in Test 90 the speed of the crash vehicle was reduced only 8.2 mph while the vehicle

TEST 88 SUMMARY

Impact Conditions
Speed: 14.4 mph
Angle: 0° (head-on)

Exit Conditions
Speed: 0.0 mph
Angle: 0°

Length of Post-Vehicle Contact: 14.3 ft

Post Damage: none

Average Deceleration: 0.43g (1.218 sec)

Note:
Vehicle brakes were not applied during test.

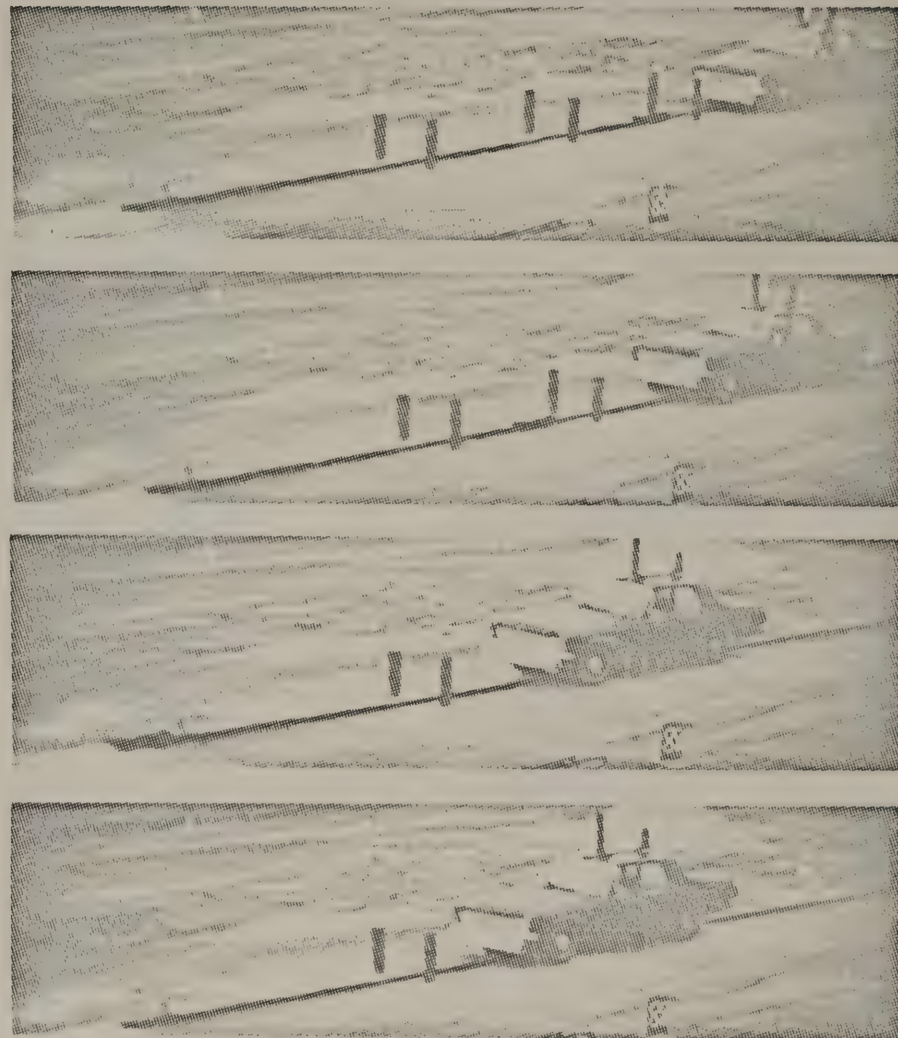


Figure 10. Rubber post speed reducer.

TEST 89 SUMMARY

Impact Conditions
Speed: 21 mph
Angle: 0° (head-on)

Exit Conditions
Speed: 0 mph
Angle: 0°

Length of Post-Vehicle Contact: 29.1 ft

Post Damage: none

Average Deceleration: 0.51g (1.900 sec)

Note:
Vehicle brakes were not applied during test.

Figure 11. Rubber post speed reducer.

TEST 90 SUMMARY

Impact Conditions
Speed: 33.9 mph
Angle: 0° (head-on)

Exit Conditions
Speed: 25.7 mph
Angle: 0°

Length of Post-Vehicle Contact: 36.4 ft

Post Damage: none

Avg. Deceleration: 0.47g (0.838 sec)

Note:
Vehicle's right front wheel off ground just before impacting Posts 5 and 6 (see third sequence shot). Vehicle brakes not applied during test.

Figure 12. Rubber post speed reducer.

was in contact with the posts. This, however, becomes a reasonable figure if one compares the kinetic energy loss of the vehicle in Test 90 to that in Test 89 where the posts just managed to stop the vehicle at 21 mph:

KINETIC ENERGY LOSS

$$KE_{loss} = \tfrac{1}{2}\, M \, (V^2 \text{ initial} - V^2 \text{ final})$$

Where: M is vehicle mass
V is velocity (in feet/sec)

TEST 89

$$KE_{loss} = \tfrac{1}{2}\, \frac{(3500)}{(32.2)}\; 30.8 - 0^2$$

$$= 51{,}556 \text{ ft-lb}$$

TEST 90

$$KE_{loss} = \tfrac{1}{2}\, \frac{(3500)}{(32.2)}\; 49.72^2 - 37.69^2$$

$$= 57{,}135 \text{ ft-lb}$$

The difference of 5,500 ft-lb in kinetic energy can be attributed to three factors: experimental error (about 10% of the values measured), the rubber posts react slightly different at different speeds (average decelerations are not identical for the two tests), and in Test 89, the vehicle did not travel completely through the complete array of posts. The speed loss of only 8.2 mph in Test 90 is what would have been predicted (±5%) using the results of Test 89.

In the photograph of the actual tests, it can be seen that in Test 89 and Test 90, there was a tendency for the front of the vehicle to rise as it hit the posts. In Test 90, if was noted that the right front wheel was off the ground. Had higher speed tests been performed the vehicle wheels might have been lifted from the pavement and loss of control might have occurred. It was decided not to perform tests at higher speeds because of

danger to equipment and personnel.

The posts in the test array were used for each test and at the conclusion of four tests there was no visible damage to the posts.

Since the box beam bumper was installed on the vehicle, no vehicle damage occurred. In our opinion had the vehicle's original bumper been in place, there still would have been no severe vehicle damage.

DISCUSSION OF RESULTS

It is important to point out that the manufacturer was present during the performance of Test 87 through 90. The manufacturer requested that vehicle brakes be locked while the vehicle was in contact with the posts; however, test engineers were interested in evaluating the ability of the rubber posts to decelerate the vehicle. They were not interested in evaluating the brakes on the test car. Therefore, vehicle brakes were not applied during testing.

The manufacturer also questioned the use of our special "box beam bumper" installed on the test vehicle. As pointed out in a previous section, the purpose of this bumper was to keep the frontal area of the vehicle uniform for all tests. Also pointed out was the fact that the "bumper" was removed for Test 90. There was no noticeable change in the post performance when the bumper was removed; therefore, we conclude that the "bumper" had no effect on test results in Test 88 and 89.

In all the tests performed, all decelerations were lower than would have been expected had the vehicle brakes been locked on clean dry pavement (in these cases decelerations are in the range of 0.6-0.8 "g's"); consequently, stopping distances in the tests were greater than they would have been in a locked wheel stop without the rubber posts.

As pointed out in Test 88 and 90, the front of the test vehicle was lifted. Since low decelerations were measured (RM-3 way accelerometer) during Tests 88, 89, and 90, it was decided to drive a test at 45 mph. In this test, the car wheels

completely left the ground and the driver lost control long enough so that he almost hit a vehicle parked near the test area. In our opinion, this lifting of the vehicle creates a serious hazard.

SUMMARY

A product marketed under the name SAF-T-POST was tested. This product could be used as a maintenance free delineator or as a vehicle speed reducer. Both applications were evaluated. The results of our findings are summarized below.

1. The manufacturer estimates that SAF-T-POSTS would cost between $70-$80 each, not including installation. It appears that this cost precludes the use of these posts as delineators.

2. The low deceleration of the test vehicle (range 0.43 to 0.51 "g's" in 3 tests) when it impacted the test array of six posts, showed that large distances would be required to stop passenger cars traveling at highway speeds. The decelerations found in these tests were lower than they would have been if the test vehicle's brakes had been applied on clean, dry pavement. (In the case of pavement, deceleration would range between 0.6-0.8 g's). A comparison of stopping distance on clean, dry pavement is shown below.

Initial Speed (MPH)	Rubber Posts		Clean, Dry Pavement
	Stopping Distance (FT) (0.45"g"decel.)	Number of Posts Required*	Stopping Distance (FT) (0.7"g"decel.)
10	7.4	4	4.8
20	29.6	6	19.0
30	66.7	8	42.9
40	118.5	12	76.2
50	185.2	20	119.0
60	266.7	28	171.4
70	362.9	38	233.3

*Assumes 2 post side by side array spaced 10' apart would be used for length of stopping area.

3. When SAF-T-POST rubber posts are set in the type of array we tested and impacted at speeds over 25 mph, there is a tendency for the front of the vehicle to be lifted. At speeds over 35 mph, the vehicle wheels can loose contact with the ground.